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*The Religion of Science.* By DR. PAUL CARUS. Chicago, The Open Court Pub. Co. 12mo. paper.

In this work Dr. Carus has undertaken to expound what he believes is to be the religion of the future. He disbelieves, as our readers doubtless know, in anything supernatural, but holds fast to the ethical teachings of Christianity and to the Christian ideal of character. It is true that he uses the Divine name frequently; but he expressly teaches that God is not a person, but merely the eternal and all-controlling power in nature. Sometimes he uses the language of pantheism; yet he insists that his doctrine is not pantheism but, as he terms it, entheism. He denies the existence of the soul as a distinct entity, and of course disbelieves in its immortality. Everything in the old religions that savors of the supernatural he regards as mythology, and maintains that it is destined to pass away, leaving nothing but the moral teachings and aspirations bequeathed to us by the prophets of old. He holds his creed with unquestioning faith, and is rather intolerant of those who still cling to the ancient creeds. "What the Roman church claims to be," he says, "the religion of science is. The religion of science is the catholic and orthodox religion." He is rather bitter against the churches for their adherence to forms and ceremonies and to what he deems erroneous doctrines, and declares that their religion is radically different from that of Christ himself. With much that he says we fully agree, and we respect the moral earnestness with which he discusses the problems of life and duty; but we are not prepared to follow him in rejecting theism, and we have much less confidence than he seems to have in some of the doctrines and criticisms that are put forth in the name of science. Yet we have read his book with interest, and we cordially echo the sentiment he expresses that "blessed is he who trusts in the truth, who hearkens to its behests, and leads a life in which obedience to truth is exemplified."

The work here noticed is to be published with others in a series entitled "The Religion of Science Library," the volumes of which will be issued bi-monthly in paper covers at 25 cents each or \$1.50 a year. The first number in the series, which bears the date of September, 1893, is a reissue of Max Müller's "Three Introductory Lectures on the Science of Thought," which was noticed in these columns when it first appeared some years ago; and other works new and old will follow in due season.

*Heat.* By MARK R. WRIGHT. Longmans, Green & Co., N. Y., 1893, 336 p. 12 mo. \$1.50.

THIS text-book of heat and thermodynamics is a well-planned and well-executed work, suitable for the classes of high schools and colleges in which an elementary course has been given, as introductory to this subject, in the usual first lessons in physics. It is made up with a view to use in connection with instruction in the laboratory, as well as in the lecture-room, and contains an excellent outline of the thermal and thermodynamic principles constituting the modern science of heat, illustrated by experiment, and enforced by numerical examples, not numerous but very carefully selected, and in every case apposite to the text. The book is, in physics, what Remsen's text-book is in chemistry, a well-prepared outline of the theory and experimental method of exposition of the science. The units employed are both the British and the metric, the C. G. S. systems. Students about to take up the applications of such principles in the advanced classes of colleges, and especially of the technical schools, will find this an excellent preparatory course. In the introduction to the chapters on thermodynamics, the work of Rumford and of Davy is given proper place, and more credit is given the former than is usual in earlier treat-

ises. Regnault's work is quite fully discussed, and the algebraic treatment of the thermodynamics of gases and vapors is unusually satisfactory. The book is printed on heavy paper, in excellent type, is well illustrated, and well bound.

*Outlines of Pedagogics.* By PROFESSOR W. REIN. Translated by C. C. and Ida J. Van Liew. London, Swan Sonnenschein & Co.; Syracuse, N. Y., C. W. Bardeen. 12mo. \$1.25.

THIS work, by the director of the pedagogical seminary at the University of Jena, is written from the standpoint of the Herbartian philosophy, and is designed to set forth Herbart's theory of education as developed and modified by his disciples. The work, like so many others that come to us from Germany, is not always easy to understand; and, though it contains much that is sound and suggestive, we doubt if it will effect any radical change either in the theory or in the practice of English and American educators. The whole book is written from a German point of view and with reference to German needs; and the division of the school system according to the German division of society into classes is assumed as something final. The parts of the book that are likely to be most interesting to American teachers are those in which the author discusses the end and aim of education and the subjects and method of instruction. The end at which all education ought to be directed is, in Professor Rein's opinion, the formation of character; and he lays such exclusive stress upon the training of the will that he almost forgets that the intellect and the feelings are entitled to consideration on their own account. Nor do we find that he offers anything essentially new as to the means of forming character; for, though he devotes considerable space to the subject, he suggests nothing to the purpose except the study of good literature and the employment of teachers of excellent character. With regard to instruction Professor Rein holds opinions somewhat different from any now prevalent in this country; and, while we cannot endorse all that he says on the subject, there is much in it that is suggestive. He holds, with Comte and others, that the education of the child ought to follow the steps that the race has taken in its historical development; but, notwithstanding the authorities that may be cited in support of this theory, we venture to think that an education based upon it would be ill adapted to the requirements of a civilized age. The importance of the right method in teaching is a subject on which the author lays great stress, and practical teachers can hardly fail to get from him some hints and warnings that will be useful. The book will serve a good purpose in drawing renewed attention to the importance of moral training, and also by presenting certain aspects of educational work that have not been generally discussed in America.

*Birds of Michigan.* By A. J. Cook. Bulletin No 94, Michigan Agricultural College. 148p. illus. 8vo.

THIS Bulletin marks something of a departure in the work of experiment stations. Most of the bulletins issued under the auspices of these wards of the Government are devoted to purely agricultural topics such as feeding of pigs or cows, dairying, planting potatoes, cultivation of corn, value of fertilizers, spraying for fungous or insect diseases and kindred subjects. Some few of the stations publish work of a high character, work which shows some originality. It must be confessed, however, that too much of the station work is of a very poor quality. Often it is a rehash of some previously issued experiments, in which the errors are copied along with the correct statements. Often it consists of descriptions of hastily made experiments which lead to no practical results; or else it may be an account of some experiment which had been tried with negative results years before, but of which the

author of the "new" experiment was totally ignorant. The present publication does not lay claim to any profound scientific knowledge or pretend to herald any new discoveries. It is a catalogue of the species of birds known to occur in Michigan, compiled from various published and unpublished data, with notes on localities and other items. There are 332 species recorded. Abstracts are given of bird and game laws, and a bibliography of over 200 references adds to the value of the whole. The illustrations, mostly taken from Coues's "Key to North American Birds," will prove of great assistance to those using the Bulletin in the state.

J. F. J.

### LIQUID AND SOLID AIR.

BY JOHN S. MCKAY, PACKER INSTITUTE, BROOKLYN, N. Y.

THE physical state, or condition, of a body is entirely incidental and never dependent upon any inherent property. The same substance may be solid in one zone and liquid or gaseous in another. According to the kinetic theory, the different states of matter are only different modes of molecular motion and any change of state is the result of the absorption or liberation of energy. By the addition of sufficient heat energy all solids and liquids become gases, and by withdrawing such energy all gases may be reduced to the liquid or solid state. It is probable that at the temperature of absolute zero ( $-273^{\circ}\text{C}.$ ) there would be neither solid nor fluid, but that if matter still continued to manifest itself to our senses, it would be in a different physical form from anything now known. It is certain that there could be no gases at that temperature, since molecular motion is essential to the idea of gaseity. From recent experiments it seems probable that all gases, under ordinary atmospheric pressure, would become liquid or solid before reaching absolute zero. It is a well-known fact that after a gas has been cooled below its critical temperature it may be reduced to the liquid state by the aid of external pressure. Until a few years ago oxygen, hydrogen, nitrogen, air, and a few other gases had never been reduced to their critical temperatures and hence could not be liquefied. Air had been compressed until it was denser than water without any trace of liquefaction. And so these gases were called permanent or incoercible gases. But in 1879 Cailletet of Paris and Pictet of Geneva, working independently and by somewhat different methods, succeeded in reaching the critical temperature of some of these gases and by great pressure reduced them to the liquid form. Since then all known gases have been liquefied and the old distinction of permanent and coercible gases has been effaced.

The critical temperature, or absolute boiling point, of these gases is very low, being  $-140^{\circ}\text{C}.$  for oxygen,  $-146^{\circ}\text{C}.$  for nitrogen, and  $-240^{\circ}\text{C}.$  for hydrogen. This low temperature is obtained by evaporating in vacuo liquid  $\text{NO}$ ,  $\text{CO}_2$ ,  $\text{SO}_2$ , or some other substance whose critical temperature is comparatively high and which is therefore easily liquefied. As yet hydrogen has been liquefied only in small quantities by allowing it to expand suddenly when at a low temperature and highly compressed. In some remarkable experiments before the Royal Society of London during the past year Prof. Dewar made use of liquid ethylene to secure the low temperature necessary to liquefy air and oxygen. By means of three concentric vessels, the outer one containing liquid nitrous oxide and the next one liquid ethylene, both being connected with powerful vacuum pumps to increase the evaporation, he secured so low a temperature in the inner vessel that oxygen, nitrogen and air were liquefied in large quantities with comparatively little pressure. By causing a vacuum to act upon a large tube containing liquid oxygen, a tem-

perature of  $-210^{\circ}\text{C}.$  was produced. A small empty test-tube inserted into the boiling oxygen was so cold that the air of the room at ordinary pressure condensed and trickled down its sides. By evaporating liquid nitrogen in a vacuum, a temperature of  $-225^{\circ}\text{C}.$  was reached, at which point nitrogen became solid.

Liquid oxygen when first formed is milky in appearance, owing to the presence of some impurity which may be removed by passing it through ordinary filter paper. When pure it is of a pale blue color, which, however, is not due, as some have thought, to the presence of liquid ozone, which is of a dark blue color. Liquid oxygen is a non-conductor of electricity but is strongly magnetic. It may be lifted from a cup by presenting the poles of a strong electro magnet. It seems to have very slight chemical activity, since it will extinguish a lighted match and has no action on a piece of phosphorus dropped into it. It is well known that the A and B lines of the solar spectrum are due to oxygen, and, from recent experiments on the top of Mount Blanc, it is thought that they are largely if not wholly due to the oxygen in the earth's atmosphere. Prof. Dewar showed that these lines come out very strong when liquid oxygen is interposed in the path of the rays from an electric lamp.

Liquid air is at first somewhat opalescent, owing probably to solid particles of carbon dioxide. It may be cleared by filtering or by standing for a few minutes, when the particles rise and disappear. When any of these liquefied gases are placed in an ordinary glass vessel they boil vigorously and soon disappear owing to the heat obtained from the vessel and surrounding objects. In a vessel made of rock salt they take the spheroidal form and last much longer, but Prof. Dewar found that they could be kept longest in vessels with double walls with high vacuum between them. A small bulb filled with liquid air and protected by a vacuum would require an hour and a half to boil away, five times as long as it could be kept in an ordinary vessel. Liquid air has the same high insulating power as oxygen but is less magnetic. Its magnetic power is evidently due to the oxygen, since liquid nitrogen is not magnetic. When the oxygen is attracted by a magnet it draws the inert nitrogen along with it without being separated, but if a sponge or ball of cotton be saturated with liquid oxygen and presented to a magnet the liquid will be drawn out of the meshes and cling to the magnet until it evaporates. The normal boiling point of nitrogen is about eight degrees below that of oxygen, so that the two substances may be separated by distillation, the nitrogen boiling off first and leaving the oxygen. But when air is being liquefied the nitrogen does not come down first, as might be expected, but the two condense together at a temperature about midway between their respective boiling points.

All the liquefied gases except oxygen and hydrogen have been frozen by self-evaporation in a vacuum. By evaporating liquid air in a vessel surrounded by liquid oxygen, Prof. Dewar succeeded in reducing the air to a clear, transparent solid. It has not yet been determined whether the oxygen of the mixture is really frozen or merely entangled among the particles of solid nitrogen in some such way as rose water in cold cream, or water in the solid gelatin of calves' foot jelly. Although pure oxygen has never been frozen it is possible that when mixed with nitrogen its freezing point is raised so that the two solidify together.

One of the interesting things connected with these recent experiments in the liquefaction of gases is the fact that it enables us to produce a lower temperature than ever before. We are slowly creeping down toward the absolute zero and the possible solution of the mysteries connected with the nature and constitution of matter. Is